

**A new species of the hermit crab genus *Diogenes* (Decapoda: Anomura: Paguroidea: Diogenidae) from Pakistan, with a comparative diagnosis of *D. guttatus* Henderson, 1888**

Feroz A. Siddiqui and Patsy A. McLaughlin

(FAS) Marine Reference Collection and Resource Centre, University of Karachi,  
Karachi-75270, Pakistan;

(PMcL) Shannon Point Marine Center, Western Washington University,  
1900 Shannon Point Road, Anacortes, WA 98221-9041B, U.S.A.

*Abstract.*—Comparison of the holotype of *Diogenes guttatus* Henderson with the Pakistani specimens attributed to that taxon has shown that they are not conspecific. The Pakistani specimens are described herein as *Diogenes tirmiziae*, sp. nov. A diagnosis of *D. guttatus*, based on the holotype, is presented for comparative purposes.

In earlier studies of the hermit crab fauna of Pakistan, Tirmizi & Siddiqui (1981, 1982) identified specimens as *Diogenes guttatus* Henderson, 1888. McLaughlin (2002b) compared Tirmizi & Siddiqui's (1981, 1982) specimens with Henderson's (1888) holotype from H.M.S. *Challenger* station 187 in the Torres Strait, off northern Australia, and with two incomplete specimens collected in the Andaman Sea, west of Phuket, Thailand. McLaughlin (2002b) concluded that while the Andaman Sea specimens were most probably conspecific with Henderson's (1888) species, the Pakistani specimens definitely were not. We have now reexamined Tirmizi & Siddiqui's (1981, 1982) material, together with specimens collected more recently, and find that they cannot be assigned to any known taxon. They are described herein as *Diogenes tirmiziae*, sp. nov. As the left chelipeds were missing from both of the Thai specimens McLaughlin (2002b) illustrated only the shield, cephalic appendages and telson. We include an illustrated diagnosis of *D. guttatus* based on the holotype, including the chela and carpus of the left cheliped.

All of the specimens of *D. tirmiziae*, sp. nov. were collected from shallow depths

along the Karachi coastal region. With the exception of two specimens that have been donated to the National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA (USNM), all specimens are deposited in the Marine Reference Collection and Resource Centre, University of Karachi (MRCRC) under the catalog prefix ANOM. The holotype of *D. guttatus* was borrowed from The Natural History Museum, London, United Kingdom (NHM).

The seeming inconsistencies between the present species description of *D. tirmiziae*, sp. nov., and the diagnosis presented by Tirmizi & Siddiqui (1982, as *D. guttatus*) are principally a matter of semantics. Inclusion of the family Diogenidae within the superfamily Paguroidea is based on the classification of Martin & Davis (2001). Terminology for the present description and diagnosis follows that of McLaughlin & Clark (1997), except for McLaughlin's (1997) definition of fourth pereopod structure. One measurement, shield length (sl), as measured from the midpoint of the rostral lobe (exclusive of the intercalary rostral process) to the midpoint of the posterior margin of the shield, provides an indication of animal size.

*Diogenes tirmiziae*, sp. nov.

Figs. 1–3

*Diogenes guttatus*—Tirmizi & Siddiqui 1981: fig. 17; 1982:57, figs. 30, 31 (not *Diogenes guttatus* Henderson, 1888).

*Diogenes* sp.—Siddiqui & Kazmi 2003:88.

*Material examined*.—Holotype, Pache, 22 Apr 2000, ♀ (sl = 2.0 mm), MRCRC ANOM 276.

*Paratypes*.—Pache: 24 Jul 1997, 1 ♀ (sl = 2.0 mm), MRCRC ANOM 274; 22 Apr 2000, 8 ♂ (sl = 1.0–3.0 mm), MRCRC ANOM 277.

Buleji: 20 Jan 1969, 1 ♂ (sl = 2.0 mm), MRCRC ANOM 125; 12 Dec 1977, 1 ♀ (sl = 2.0 mm), MRCRC ANOM 225; 03 Oct 1990, 4 ♂ (sl = 1.8–2.3 mm), MRCRC ANOM 273, 2 ♂ (sl = 2.2, 2.5 mm) USNM 1009965.

Katti Bunder: 28 Jan 1975, 12 ♂ (sl = 1.0–2.5 mm), 2 ♀ (sl = 1.0, 2.0 mm) MRCRC ANOM 186.

Sandpit: 29 Oct 1999, 1 ♂ (sl = 3.5 mm) MRCRC ANOM 275; 24 Apr 2002, 10 ♂ (1.0–2.4 mm), 10 ♀ (sl = 1.0–2.0 mm), MRCRC ANOM 278.

*Description*.—Shield (Fig. 1A–D) slightly broader than long to slightly longer than broad; anterior margin between very broadly rounded rostral lobe and lateral projections somewhat concave and often with few minute or tiny tubercles; anterolateral angles usually spinulose, lateral margins each usually cut by several transverse, spinulose or tuberculate ridges, each extending onto lateral surfaces of shield; posterior margin truncate; dorsal surface with additional few scattered spinules and tufts of sparse setae. Lateral projections triangular, often with tiny to small marginal or submarginal spine or spinule. Dorsal margins of branchiostegites each with 5–8 moderately small spines, partially obscured by fine setae.

Ocular peduncles 0.6–0.8 length of shield, moderately stout, each with rows of tufts of very sparse setae dorsomesially and mesially; corneal diameter 0.2–0.3 of peduncular length. Ocular acicles subtriangu-

lar, anterior margin with 2–4 prominent spines and usually 3 or 4 additional spinules, innermost spine often distinctly thicker and sometimes with curved tip; acicles basally separated by approximately 0.2 or less width of one acicle. Intercalary rostral process stout proximally, frequently drawn out into long slender terminal spine, but not overreaching apices of innermost acicular spines; no ventral spine.

Antennular peduncles moderately slender, when fully extended overreaching corneas by 0.2–0.5 length of ultimate segments. Ultimate and penultimate segments unarmed, but with few tufts of moderately long setae. Basal segment with few shorter setae.

Antennal peduncles (Fig. 1E–H) not quite reaching or slightly overreaching distal corneal margins; with supernumerary segmentation. Fifth segment with scattered setae dorsally and 2 rows of long setae ventrally. Fourth segment unarmed, but with tuft of moderately long setae dorsally. Third segment with tuft of long setae on ventrodistal margin. Second segment with dorso-lateral distal angle usually produced into prominent spine, 3–5 additional spines on laterodistal margin ventrally (not visible in dorsal view), dorsomesial distal angle with or without acute spine, mesial margin with tufts of setae. First segment usually with 1 or 2 small spines at dorsolateral distal angle, lateral margin with few tiny spinules ventrally. Antennal acicle short, broad, with distally oblique margin armed with 3–5 very prominent spines and few setae. Antennal flagellum short, often not reaching to proximal margin of palm of left cheliped; each article with pair of long, pinnate setae.

Maxillule with endopod lacking external lobe. Third maxilliped with inner margin of coxal plate denticulate; 1–3 small spines on basis; ischium with crista dentata composed of 6–9 small corneous teeth.

Left cheliped (Fig. 2A–D') with dactyl slightly shorter to approximately as long as upper margin of palm, prominently arched; cutting edge with row of small calcareous

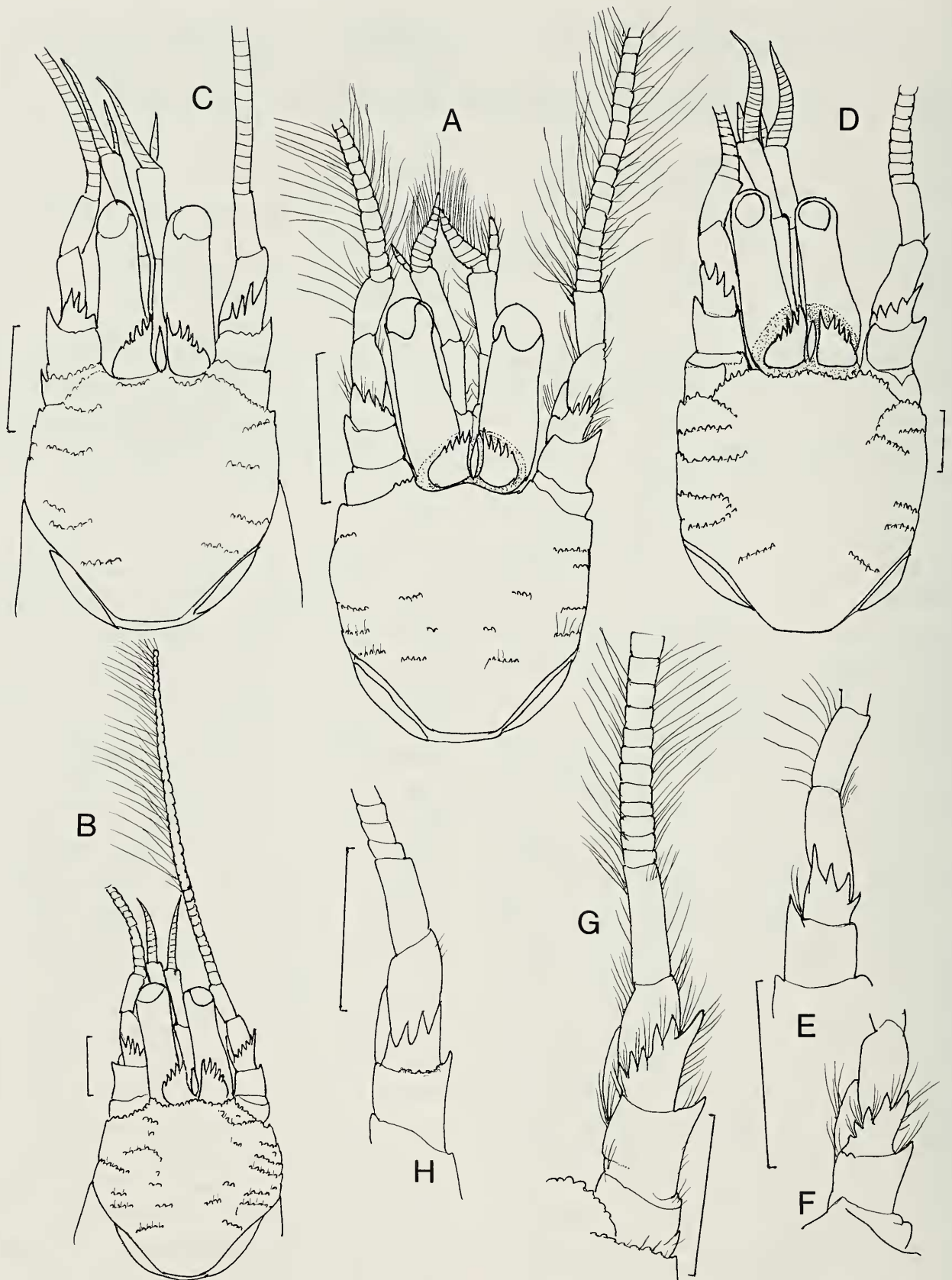


Fig. 1. *Diogenes tirmiziae* sp. nov.. A, E, F, holotype female, sl = 2 mm, MRCRC ANOM Cat. No. 276; B–D, G, H, paratype males, sl = 2.5–3 mm, MRCRC ANOM Cat No. 277. A–D, shield and cephalic appendages (setae and aesthetascs generally omitted); E–H, antennal peduncle and acicle (setae often omitted). E, H, left; F, G, right. Scales equal 1 mm.

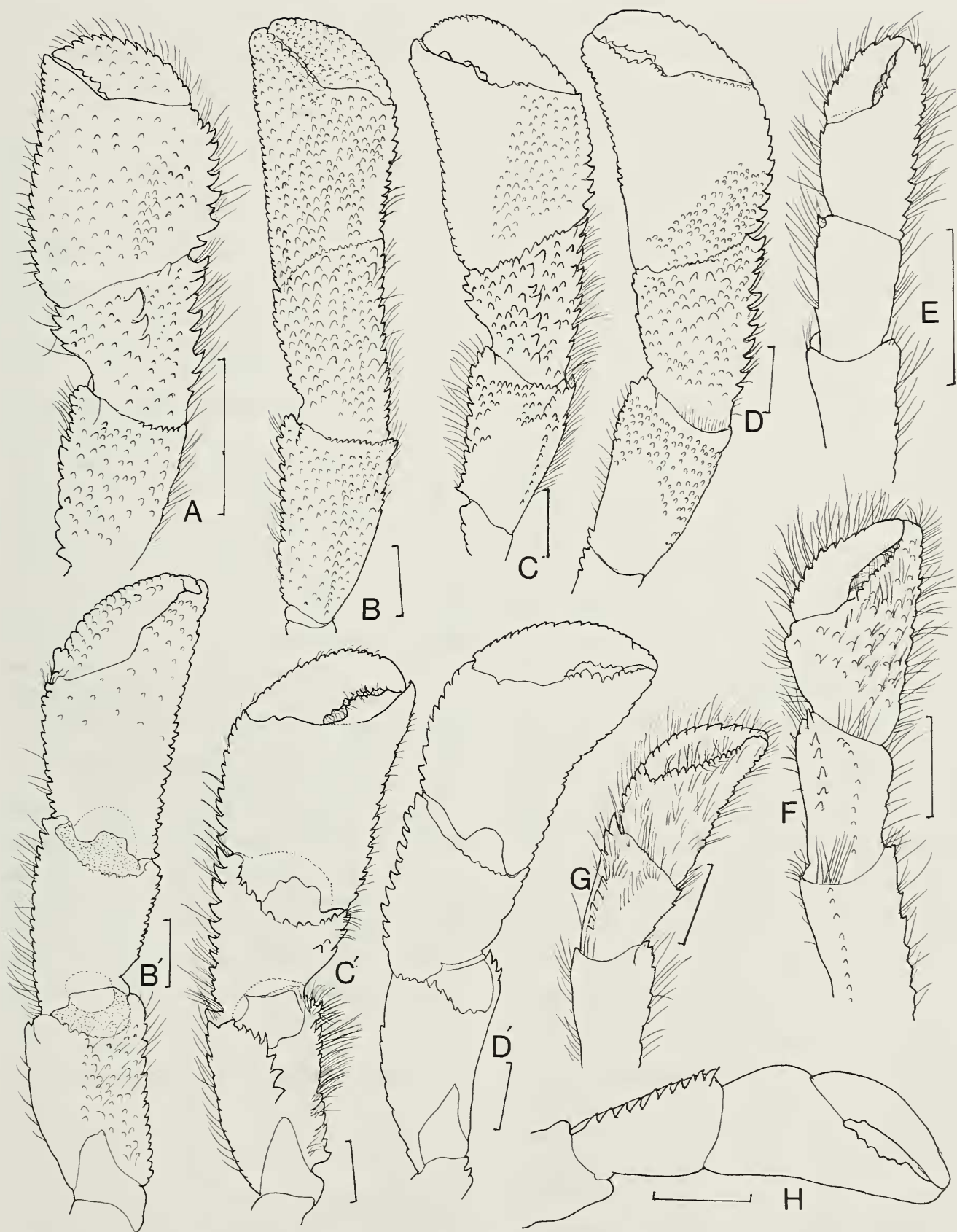


Fig. 2. *Diogenes tirmiziae* sp. nov. A, E, holotype female, sl = 2 mm, MRCRC ANOM Cat. No. 276; B-D, F-H, paratypic males, sl = 2.5-3 mm, MRCRC ANOM Cat. No. 277. A-D, left cheliped (dorsolateral view) (setae and full armature sometimes omitted); B'-D' left cheliped (ventrolateral view) (setae and armature sometimes omitted); E-H, right cheliped (dorsolateral view) (setae and armature sometimes omitted). Scales equal 1 mm.

teeth and frequently 1 larger tooth proximally; terminating in large calcareous claw, sometimes overlapping fixed finger; outer surface generally flattened, armature varying from longitudinal row of moderately small, subacute to blunt, tuberculate spines and short row of small spinules adjacent to cutting edge in distal 0.25 to complete covering of closely-spaced, small, conical tubercles; upper margin with 2 rows, sometimes coalesced, of subacute or blunt spines forming transverse, low ridges over full length of margin; inner surface varying from smooth and glabrous, or with row of shallow pits and sparse very short setae extending nearly to tip and flanked proximally by few very small tubercles, to overall weakly tuberculate. Fixed finger with lower margin often not distinctly delimited, but with almost double row of small rounded tubercles and forming straight line with similarly armed lower margin of palm; outer surface somewhat convex, with covering of small drop-like, spinulose tubercles, sometimes simply ovate tubercles; inner surface often with 2 rows of very shallow pits and sparse tufts of very short setae, rows divergent proximally, but converging toward tip, sometimes with scattered tubercles; cutting edge with row of small calcareous teeth and 1 larger tooth proximally; terminating in large calcareous claw. Palm with outer surface angularly convex and with covering of small, drop-like, frequently spinulose tubercles, often larger near upper margin, short longitudinal row of 4 small, tuberculate spines proximally in upper 0.2 sometimes evident; upper margin with irregular single to double row of small to moderately-sized, subacute, tuberculate spines, ventral margin not delimited and no prominent spines or tubercles at or near ventroproximal angle; inner surface usually tuberculate. Carpus equal to or slightly longer than palm and approximately equal to length of merus; armature of upper margin varying from irregular double row of small, tuberculate spines to similarly double row of prominent acute or subacute spines, outer

face angularly convex, upper 0.3 relatively flat and with scattered very small tubercles to well developed spines, angular 0.3 with more numerous and slightly more prominent, larger tubercles or spines, lower 0.4 with covering of much smaller tubercles, lower margin not delimited, but with somewhat larger tubercles or tuberculate spines; inner surface with scattered small tubercles and sparse, moderately long setae. Merus subtriangular; distal margin occasionally with row of prominent spines extending laterally and mesially; dorsal surface tuberculate or with short, transverse, spinulose or spinose ridges and with tufts of moderately long setae; lateral face tuberculate, tubercles often larger near ventral margin, ventromesial margin tuberculate or with row of small spines; mesial face weakly tuberculate, distal margin with several spines or at least with 2 small spines ventrally, ventromesial margin with tubercles and few small tuberculate spines or row of small to prominent spines; ventral surface weakly tuberculate. Ischium with tuberculate ventral surface, ventromesial margin tuberculate or with row of small spines.

Right cheliped (Fig. 2E–H) appreciably shorter than left, usually not reaching proximal margin of palm of left; dactyl and fixed finger with prominent hiatus. Dactyl slightly longer than palm, arched; upper margin with 2 rows of low, spinulose tubercles or small spines, accompanied by numerous long, fine, simple setae and separated by moderately broad, shallow sulcus; outer surface often with 2 rows of low, spinulose tubercles or small spines, also accompanied by long setae; cutting edge with row of small calcareous teeth, at least proximally, terminating in moderately large calcareous claw and slightly overlapped by fixed finger. Palm with irregular rows of spinulose tubercles or small spines on upper surface; outer surface with small, spinulose tubercles or small spines, often forming irregular rows and partially obscured by long setae; outer face of fixed finger similarly armed; lower margin with row of subacute

spines and long setae; cutting edge with row of small calcareous teeth, terminating in moderately large calcareous claw. Carpus with row of small to moderately large spines on upper margin and adjacent row of slightly smaller spines on outer face, both partially obscured by numerous long setae, remainder of outer face granular, minutely tuberculate, or spinulose, lower margin not delimited; inner and lower surfaces with scattered long setae. Merus usually with numerous long setae arising from low protuberances or tubercles on dorsal margin; lateral face weakly tuberculate or granular, ventrolateral margin unarmed, with 2 or 3 very small spines distally, or with row of small spines; ventromesial margin with row of small spines or spinulose tubercles and long setae. Ischium with ventromesial margin unarmed or with row of very small spines or tubercles, and with few long setae.

Second and third pereopods (Fig. 3A–H) with dactyls approximately equal to or 0.1–0.2 longer than propodi, somewhat curved, but not twisted; terminating in moderately small corneous claws; dorsal surfaces with numerous long, simple setae, ventral surfaces with each row of tufts of sparse, short setae; mesial and lateral faces each with shallow longitudinal sulcus and scattered, moderately long setae. Propodi each with dorsal row of small spines not obscured by tufts of sparse, long setae, spines smallest on third pereopods or occasionally distinguishable only distally, lateral and mesial faces each with 1 or 2 rows of tufts of sparse setae, surfaces sometimes with tiny tubercles or protuberances. Carpi each with row of small to moderately large spines and long, simple setae on dorsal margin, spines of third pereopods usually appreciably smaller, occasionally only low protuberances; mesial, lateral and ventral surfaces with rows of moderately long setae, lateral faces sometimes also tuberculate. Meri with tufts of moderately long setae on dorsal surfaces, ventral surfaces of second pereopods each with irregular row of small spines or tubercles and tufts of setae, ventral surfaces of

third pereopods often with low protuberances and tufts of setae. Ischia with long setae dorsally and ventrally. Fourth pereopods semichelate. Anterior lobe of sternite of third pereopods divided by shallow, longitudinal median groove, each half with 1 small tuberculate spine accompanied by tuft of setae.

Male unpaired left pleopods uniramous, marginally very setose. Female with paired gonopores; unpaired left pleopods 2–4 well developed, biramous; pleopod 5 as in male. Telson (Fig. 3I–K) with median cleft; left terminal margin with row of relatively uniform, small spines, 1–3 much larger spines at or near outer angle and several smaller spines continued down lateral margin; right terminal margin with row of relatively uniform small spines, usually not continued down lateral margin.

*Color* (in life).—Carapace light orange with pale green and brownish spots. Shield with transverse bands of brown. Intercalary rostral process and ocular acicles green; ocular peduncles brown proximally, bright orange distally with median dark brown bands. Antennular and antennal peduncles and flagella with alternating bands of brown and cream. Left chela dark brown, remaining segments banded green and brown (after Tirmizi & Siddiqui 1982).

*Habitat*.—Rocky shores (Siddiqui & Kazmi 2003).

*Distribution*.—Known only from the Karachi coast of Pakistan.

*Etymology*.—This species is named in honor of Dr. N. M. Tirmizi, former director of the Marine Reference Collection and Resource Centre, and noted Pakistani carcinologist.

*Diogenes guttatus* Henderson, 1888

Fig. 4

*Diogenes guttatus* Henderson, 1888:54, pl. 6, fig. 4, 4a.—Alcock 1905:166.—Gordan 1956:317.—Morgan & Forest 1991:664.—McLaughlin 2002b:411, fig. 1A, B. Not *Diogenes guttatus*—Tirmizi & Siddiqui

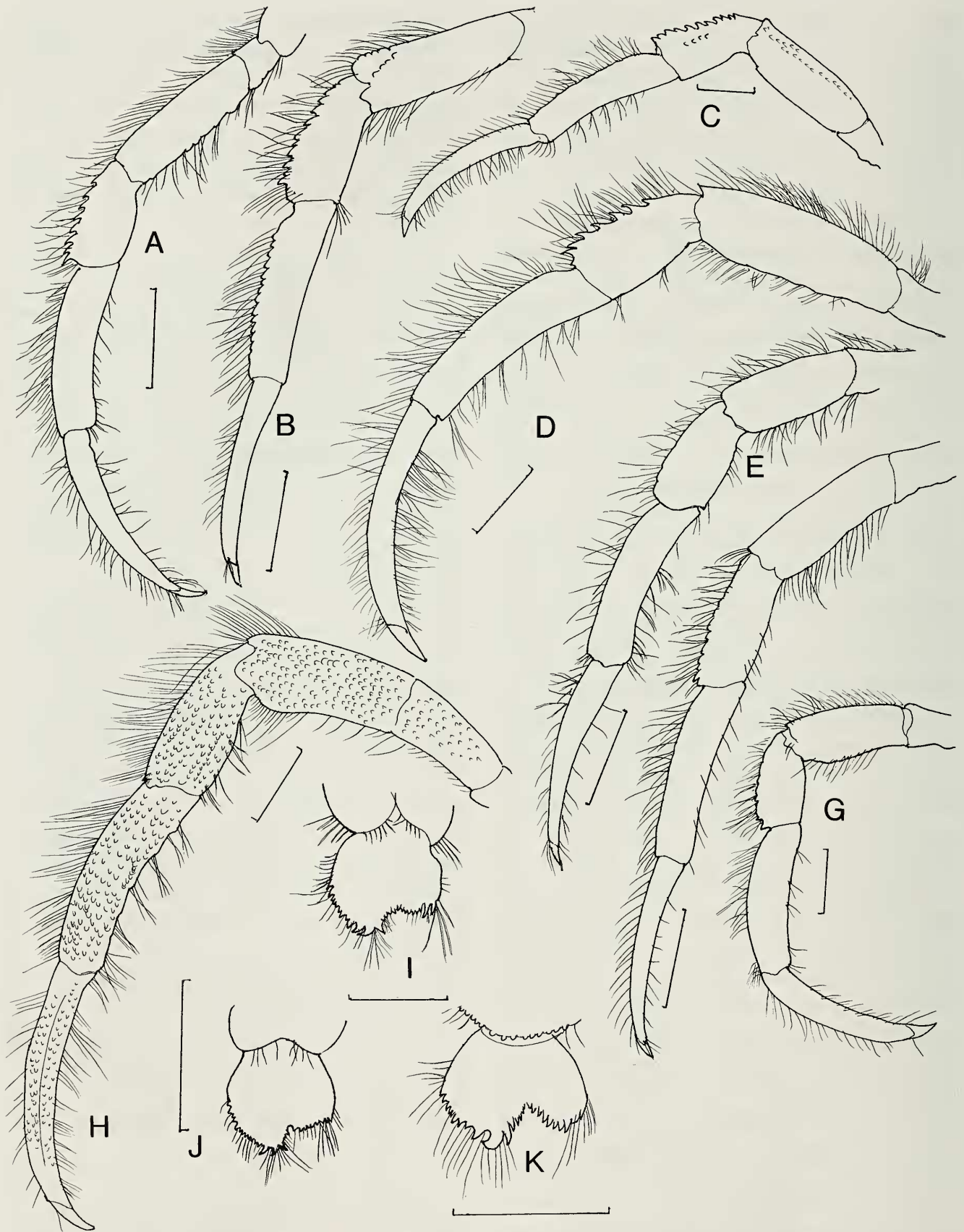


Fig. 3. *Diogenes tirmiziae* sp. nov. A, E, I, holotype female, sl = 2 mm, MRCRC ANOM Cat. No. 276; B-D, F-H, J, K paratypic males, sl = 2.5-3 mm, MRCRC ANOM Cat. No. 277. A-D, left second pereopod (lateral view); E-H, left third pereopod (lateral view); I-K, telson (dorsal view). Scales equal 1 mm.

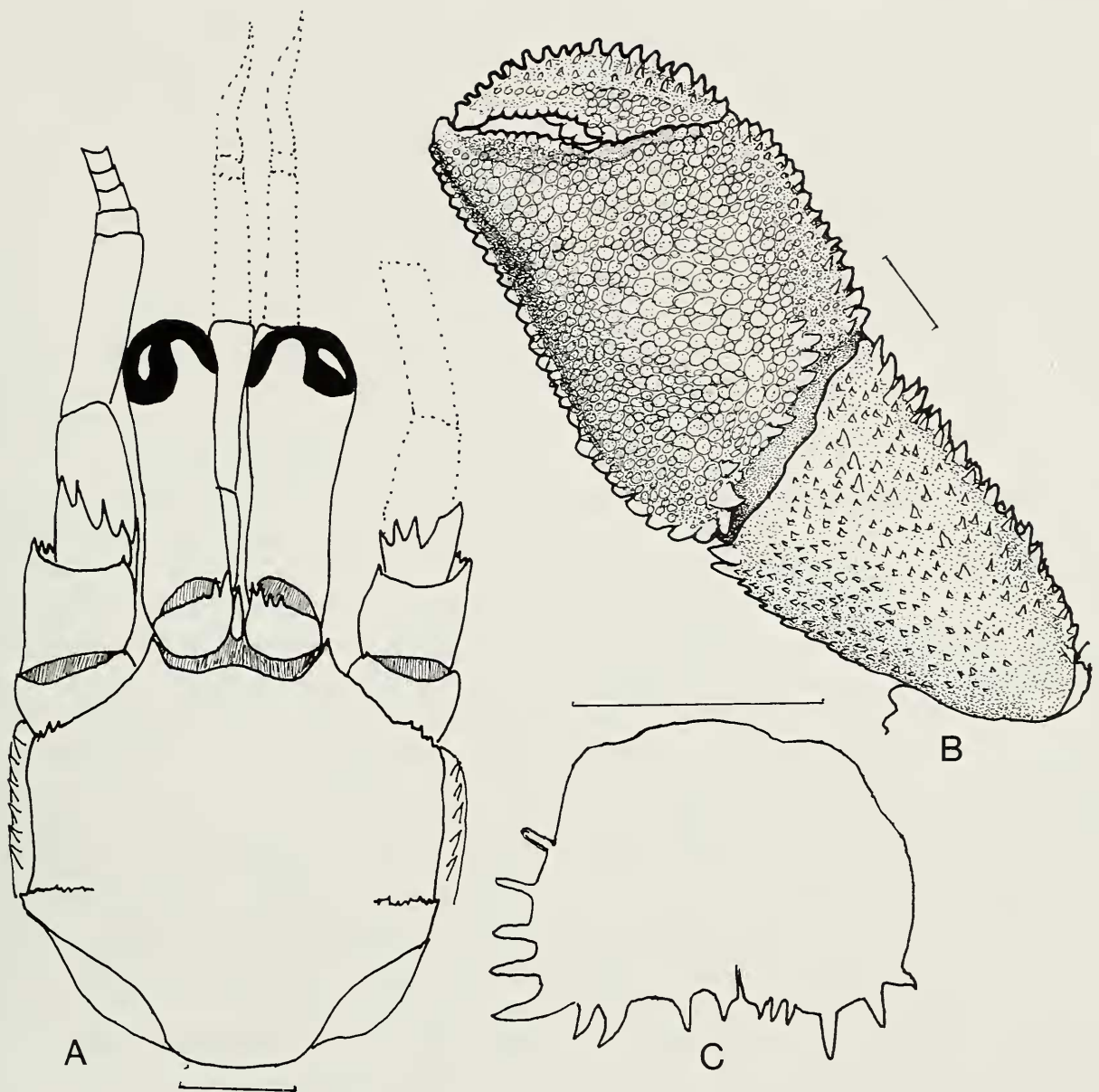


Fig. 4. *Diogenes guttatus* Henderson, 1888. holotype male sl = 3.1 mm, NHM 1888.3.1. A, shield and cephalic appendages (setae and aesthetascs omitted); B, chela and carpus of left cheliped (dorsolateral view); C, telson (dorsal view). Scales equal 1 mm.

1981: fig. 17; 1982:57, figs. 30, 31 (= *Diogenes tirmiziae*, sp. nov.).

*Material examined*.—Holotype ♂ (sl = 3.2 mm), *Challenger* station 187, 10°36'S, 141°55'E, 11 m, 9 Sep 1874, NHM 1888.33.1.

*Diagnosis*.—Shield (Fig. 4A) slightly convex, centrally smooth; lateral margins each with protuberant spinulose ridge in proximal half. Rostrum obsolete; lateral projections produced. Margins of branchiostegites with 5 (right) or 6 (left) acute spines. Intercalary rostriform process simple, tapering to acute tip, not reaching to

apices of acicular spines. Ocular peduncles (including corneas) reaching approximately to midpoint of ultimate segments of antennal peduncles and proximal margins of ultimate antennular peduncular segments; ocular acicles with 2 or 4 spinules on distal margin, innermost largest. Second segment of antennal peduncle with row of small spines on lateral margin ventrally, 1 small spine at dorsolateral distal angle and smaller spine at dorsomesial distal angle. Antennal acicle short, broad, generally subquadrate, outer spine not reaching beyond midlength of penultimate peduncular segment,



anterior margin with 3 additional prominent spines. Antennal flagellum shorter than twice carapace length, articles each with pair of long ventral setae.

Left cheliped (Fig. 4B) with row of small spines on upper margin of dactyl and numerous spinules and flattened tubercles on outer surface. Outer surface of palm covered with circular, mushroom-shaped, flattened tubercles, upper and lower margins spinose and almost straight; proximal margin with 3 moderately stout short spines near lower angle and 4 subacute spines at mid-length, slightly curving onto outer face. Carpus with irregular double row of small spines on upper margin; outer surface with covering of spinules, more dense in lower half. Right cheliped missing.

Ambulatory legs with dactyls slightly curved, longer than unarmed propodi. Carpi of second pereopods each with row of small spines on dorsal margin; third with row of very small spinules on dorsal margin. [Henderson (1888) incorrectly reported these spines as being on the meri.]

Telson (Fig. 4C) with slender median cleft; left lobe with 4 moderately large spines on terminal margin, 1 more elongate spine at outer angle and 4 large spines on posterior 0.5 of lateral margin; right posterior lobe with 3 small and 3 larger spines on terminal margin, outer 2 actually extending onto rounded outer angle.

*Color*.—Not reported.

*Habitat*.—Coral mud.

*Distribution*.—Northern Australia; Andaman Sea; 11–61 m.

### Discussion

That Tirmizi & Siddiqui (1981, 1982) mistook *Diogenes tirmiziae*, sp. nov., for Henderson's (1888) *D. guttatus* is not surprising. At that time, Henderson's taxon had not been reported since the original description except in the literature citations of Alcock (1905) and Gordan (1956). The armature of the left chela of *D. guttatus* was described by Henderson (1888:54) as "per-

fectly circular, drop-like and flattened"; however his (loc. cit., pl. 6, fig. 4) illustration of the chela was quite small and not very definitive. The spination of the palm of the left chela of *D. tirmiziae*, although not flattened, also can be described as circular and drop-like. More importantly, *D. guttatus* and *D. tirmiziae* share a rather distinctive type of antennal acicle, (i.e., Henderson 1888, pl. 6, fig. 4a; Tirmizi & Siddiqui 1982, fig. 30D), and it is undoubtedly this similarity that led Tirmizi & Siddiqui (1981, 1982) to believe that they were dealing with *D. guttatus*. A third species, also described on a single male, *D. dorotheae* Morgan & Forest, 1991, shares with *D. guttatus* and *D. tirmiziae* those characteristic, very truncated antennal acicles. Morgan & Forest differentiated *D. dorotheae* from *D. guttatus* by the circular, drop-like and flattened armature of the left cheliped of the latter species, as well as the presumed spinose dorsal margins of the meri of the ambulatory legs. As noted in our diagnosis of *D. guttatus*, and also pointed out by McLaughlin (2002b), it is the dorsal margins of the carpi of the ambulatory legs, not the meri, that are spinose. All three species share this character; however, unlike *D. guttatus* and *D. dorotheae*, *D. tirmiziae*, sp. nov., also has a row of spines on each propodus.

Morphological variability and sexual dimorphism in species of *Diogenes* have been reported frequently (e.g., Forest & Guinot 1956, Rahayu & Forest 1995, McLaughlin 2002a), and as can be seen in the species' description, *D. tirmiziae*, sp. nov., exhibits considerable variation in the strength and armature of the left cheliped. As the chelipeds of both *D. guttatus* and *D. dorotheae* are known only from their male holotypes, variation in these species cannot be assessed. However, despite the described differences in the structure of the tubercles in *D. guttatus* (mushroom-shaped and flattened) and *D. dorotheae* (short to long, acute to blunt, and cylindrical), the species share one character that is not found in *D.*

*tirmiziae*, i.e., 3 or 4 prominent acute spines near the lower proximal angle of the outer face of the left palm. The longer dactyls of the ambulatory legs and appreciably denser pilosity described for *D. dorotheae* also would distinguish this species from *D. tirmiziae*, as the mushroom-shaped tubercles of *D. guttatus* set it apart from all known species of *Diogenes*.

Morgan & Forest (1991) also differentiated *D. dorotheae* from *D. guttatus* by the bifid intercalary rostral process of their species; however, as was shown by McLaughlin (2002a) a bifid process is not a useful diagnostic character. Morgan & Forest (1991) noted another species that had been described on a single specimen collected in northwestern Australia, *D. granulatus* Miers, 1880. Siddiqui & Kazmi (2003) reported, on the basis of a remark by McLaughlin (pers. comm.), that there could be a remote chance that the species identified as *D. guttatus* from Pakistan might actually be referable to Miers' (1880) taxon. *Diogenes granulatus* was briefly described by Miers in a footnote to his discussion of "*Diogenes miles*" (not *D. miles* Fabricius, 1787, cf. McLaughlin & Holthuis 2001) but was never illustrated nor has it been knowingly collected again. Efforts to locate the holotype in the Natural History Museum collections presently have been unsuccessful (P. F. Clark, pers. comm.). However, Miers' (1880) related *D. granulatus* to *D. avarus* Heller, 1865, which suggests that the antennal acicles were of the usual triangular configuration seen in most species of *Diogenes*. Additionally, Miers' (1880) report that the ocular acicles of *D. granulatus* were "entire" and the fixed finger of the left chela was prominently deflected support our conclusion that the Pakistani species is not conspecific with *D. granulatus* any more than it is with *D. guttatus*.

#### Acknowledgments

We acknowledge, with thanks, the efforts of Paul F. Clark to locate the holotype of

*D. granulatus* and for the loan of the holotype of *D. guttatus*. We also are very grateful to Prof. Dr. Quddusi B. Kazmi, Director, Marine Reference Collection and Resource Centre, University of Karachi, for providing research space and facilities in the Centre to the first author. This is, in part, a scientific contribution from the Shannon Point Marine Center, Western Washington University.

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